CHAPTER C.16
LITERATURE REVIEW OF AVAILABLE DATA AND PREVIOUS STUDIES IN REGION 4: A BASIS FOR WATER AND SEDIMENT BUDGETS

Ehab Amin Meselhe[1]
John Andrew Nyman [2]
John Foret[3]
Erick Swenson[2]
Darryl Clark[4]
Christopher Swarzenski[5]
Emad Habib[1]
John Alexander McCorquodale[6]
Karim Keiashy[7]

[1] *University of Louisiana at Lafayette*

[2] *Louisiana State University*

[3] *US Department of Commerce, National Marine Fisheries Service*

[4] *US Fish and Wildlife Service*

[5] *United States Geological Survey*

[6] *University of New Orleans*

[7] *C.H. Fenstermaker*

16.1 Abstract/Summary

The objective of this task is to identify all available hydrologic and ecologic data for Region 4. Another goal of this effort is to identify and gather reports of previous studies that may be of help in developing comprehensive water and sediment budget analyses, and to setup region-wide comprehensive hydrodynamic, salinity, and sediment modeling tools.

Region 4, also known as the Chenier Plain, extends from Fresh Water Bayou west of Vermilion Bay to Sabine Lake. It is the western most region of Louisiana's coast and extends across the boarder to the State of Texas. The hydrologic and ecologic characteristics of this region are unique and quite challenging to fully understand. Therefore, a better understanding of the hydrology (water and sediment) and ecology of the region is essential to a successful implementation of an ecosystem-scale wetland restoration plan. However, an accurate

accounting of water and sediment volumes in the region is lacking. Such information is critically needed for the success of future sound modeling efforts that can be used to assess region-wide restoration plans and strategies. Therefore, as a first step toward developing comprehensive water and sediment budget analyses and comprehensive numerical modeling tools, all available data and field measurements in this region need to be identified and compiled, and published reports and technical papers of studies in this region need to be gathered.

Large bathymetric surveys and datasets of open water bodies and channels, as well as marsh elevations were identified. GIS maps showing the location and density of the data are included with this report. Moreover, continuous and discrete monitoring stations along with the type and frequency of data gathered at each gage has been documented and archived in a database.

The following issues were identified as major obstacles in the way of developing a region-wide understanding of the hydrology and ecology. These issues should be addressed thoroughly and immediately.

- No surveying data are available for the four major lakes in the area, namely, White, Grand, Calcasieu, and Sabine lakes (1982 data available for the Calcasieu and Sabine). There is a "hypothesis" that sediment and nutrients from uplands deposit in these lakes. Only through including these lakes into the planned region-wide numerical models, will this hypothesis be clarified.
- Adequate marsh-elevation data are not available everywhere within the region. Additional marsh-elevation shots may be collected near the primary and secondary surveying monuments. Such data will provide nearly uniformly distributed marsh-elevation data throughout the region. Being near already existing surveying monuments drastically reduces the cost of collecting such data.
- Adequate information regarding the sediment plume from the eastern side of the state is not available. It is anticipated that such information will be crucial to future restoration plans for the region.
- A region-wide hydrodynamic, salinity, and sediment model does not exist. Such a model will be the primary analysis and evaluation tool for future restoration projects.
- Only limited hydrologic and ecologic data exist for the marsh areas. Therefore, numerical models ability to provide predictions is limited. It is anticipated that the statewide CRMS program will address this issue.
- The role of coastal zone processes (waves, tides, storm surges and season fluctuations in the Gulf of Mexico) on the water, salinity and sediment budgets of the Chenier Plain is poorly defined. More field monitoring and system modeling are needed to understand how these processes contribute to the coastal morphology.

Through historical records, previous studies, and experience, the committee has identified that the availability of salinity and water level information both in the open water and especially in the marsh are crucial factors for evaluating any future plans for the regions. Sediment and nutrient distributions, although important, are probably secondary to salinity and marsh hydro-

period patterns as causes of land loss. Nevertheless, the region-wide numerical model ought to include all four: water level, salinity, sediment, and nutrient information.

16.2 Background

The Chenier Plain consists of two main basins, the Mermentau and Calcasieu-Sabine basins. The Mermentau Basin comprises two sub-basins, the Lakes Sub-basin, located south of the limit of the coastal zone and north of Louisiana Highway 82, and the Chenier Sub-basin, which lies between Louisiana Highway 82 and the Gulf of Mexico. The Calcasieu-Sabine basin includes two major lakes, Calcasieu and Sabine, separated by the Sabine National Wildlife Refuge.

There have been numerous studies conducted in this area for the past several decades in an effort to understand the hydrology and ecology of the system, and to understand the causes of wetland loss (e.g., Gammill et al., 2002, Gosselink 1979, Valentine, 1978, Penland and Suter 1989, Morton 1973, Gould and McFarlan1959, Wells and Kemp 1981, Gunter and Shell 1958). Additional studies are listed in the bibliography attached to this proposal.

There has been a great deal of knowledge gained through these studies. Based on such studies several successful restoration projects have been implemented in the area. There are future plans that are currently being considered. Although many aspects of the future plans are sound and beneficial, some gaps in our knowledge of the hydrology and ecology of the region still exist and should be addressed. A region-wide understanding will be a key factor in improving the future restoration plans for the region and will provide further assurance for their success.

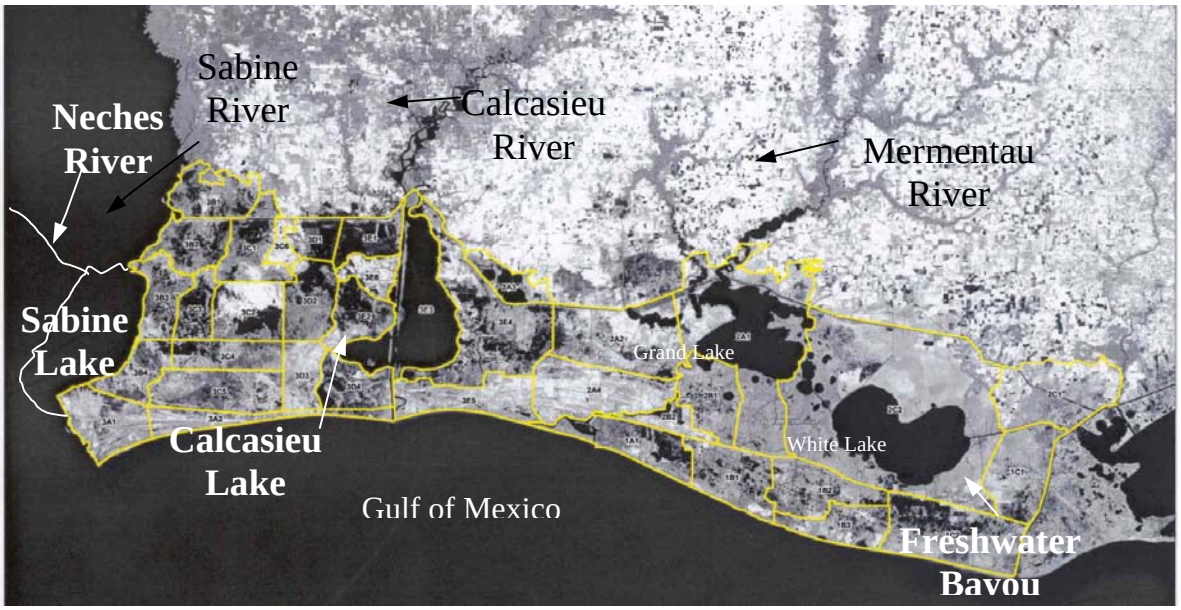

Figure C.16-1: General map showing the boundaries of the Louisiana Chenier Plain

The changes and alterations to the hydrology of the region are many and due to the limited space could not all be listed in here. The major changes, however, include large ship channels, namely, the Calcasieu and Sabine-Neches, and the Gulf Intracoastal Waterway (GIWW).

Additional changes include navigation improvements, flood control, agriculture, and petrochemical exploration. All these changes have dramatically altered the hydrology of the system, and specifically, the overall water circulation within and around the system, the marsh hydro-period, and the salinity regime.

16.3 Available Data

There is a wealth of data available for this region. The committee has decided to compile all available data in a GIS database. The purpose of the database is to organize the information such that an evaluation of the density and availability of parameters can be easily performed. The units and coordinate system of data has been unified prior to incorporation into the GIS database.

The database include the following information:

- Bathymetry: recently surveyed marsh elevation, waterways and lake bottoms including LIDAR data. A sample of the information gathered thus far is shown in Figure C.16-2.
- Available water level, discharge, salinity, and sediment data (continuous and discrete) are being gathered. Sample of the continuous data is shown in Figure C.16-3, while a sample of the discrete data is shown in Figures C.16-4 and C.16-5. The dates of each record, and the parameter collected are stored in the GIS database. In Figure C.16-3, the obvious gap in the continuous data is at the outlets of this region to the Gulf of Mexico. This gap must be addressed in order to conduct a comprehensive budget analysis
- Ecological data are somewhat limited. However ecological scientists among the committee members (namely, Dr. John Foret of NMFS and Dr. Andy Nymanof LSU) have useful data for future ecological models. Currently, the GIS database includes some discrete information that was collected in the past.

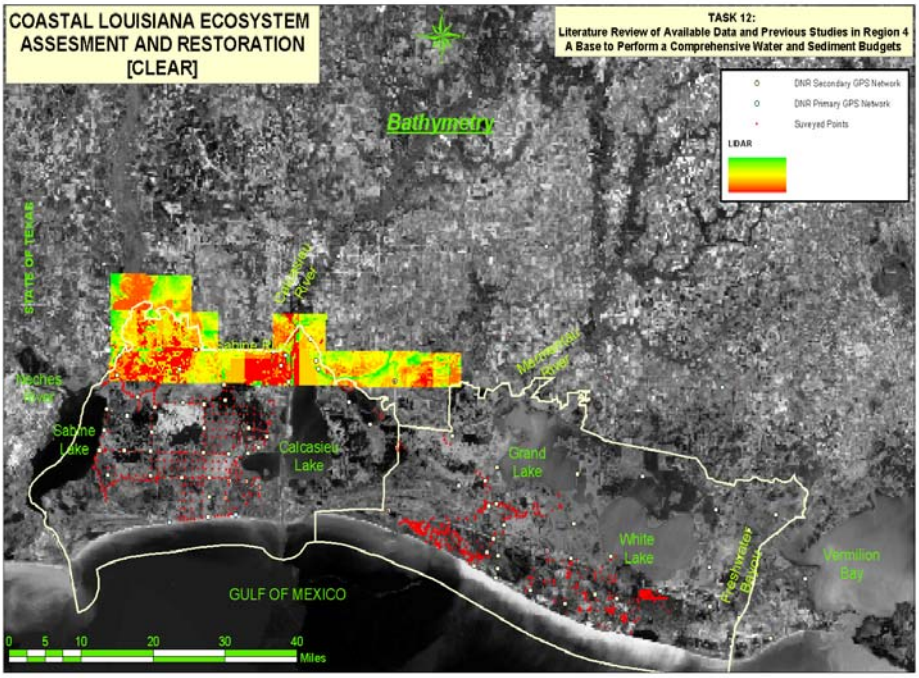

Figure C.16-2: Sample of available bathymetric data in sub-province 4 as of July 2004.

The effort of collecting historical records is always tedious and time consuming. Therefore, it is envisioned that this comprehensive database will serve as an excellent foundation for future work in this region.

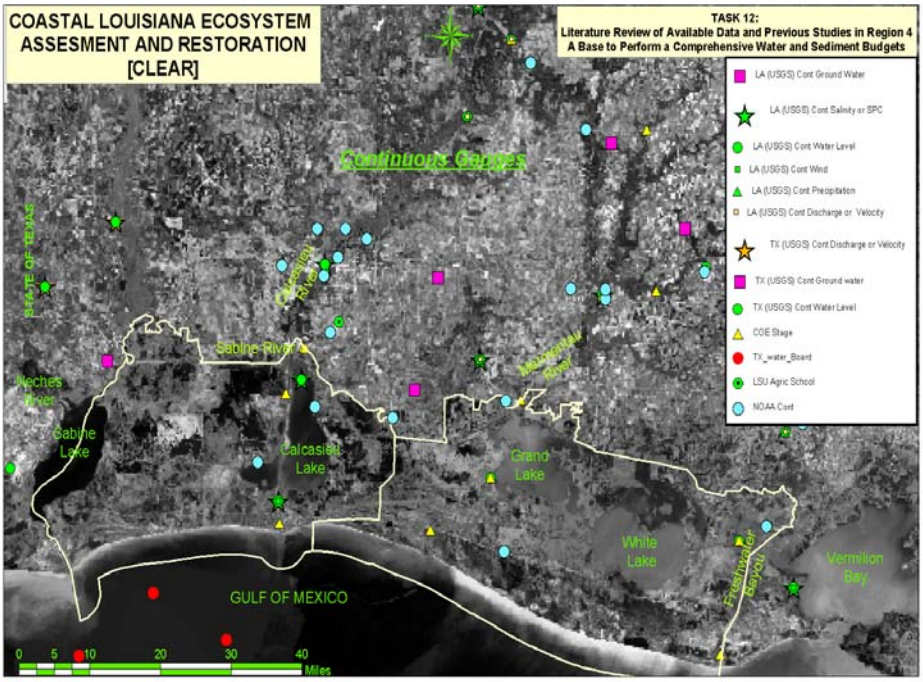

Figure C.16-3: Sample of the continuous monitoring stations in sub-province 4.

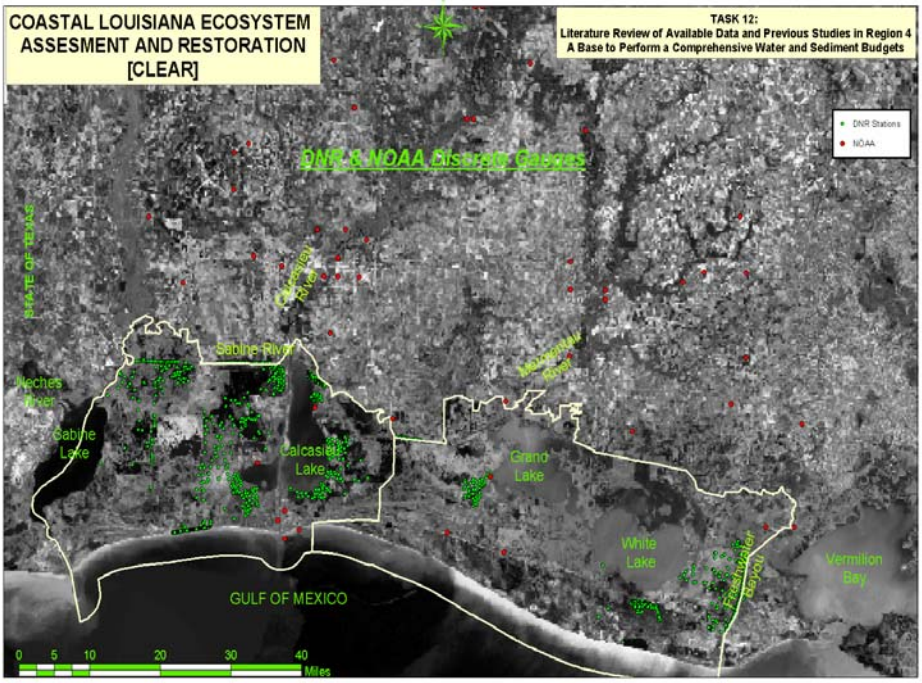

Figure C.16-4: Sample of the historical discrete data in sub-province 4.

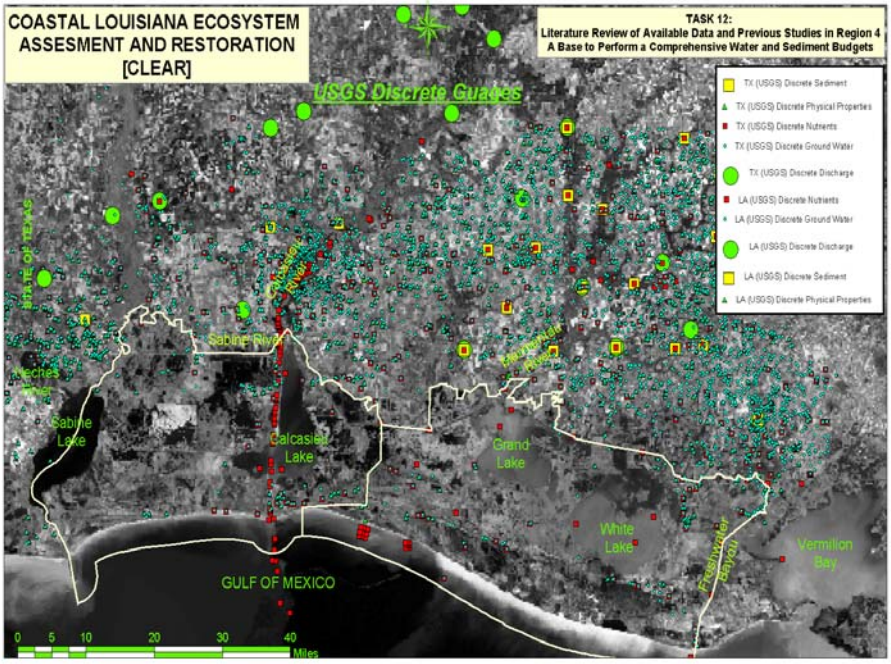

Figure C.16-5: Additional historical discrete data in sub-province 4.

16.4 Previous Modeling Efforts within Sub-Province 4

Reviews of all previous modeling efforts indicate that a sub-province wide numerical model does not exist. The following brief list shows the most recent modeling efforts within this region:

Calcasieu-Sabine 3D model: This model includes the Sabine and Calcasieu Lakes and the Sabine National Wildlife Refuge. It extends north to include the Calcasieu, Sabine, and Neches rivers, and south to the Calcasieu and Sabine passes. However, this model does not include marsh elevations. This is probably the largest scale model available within this region. It is a three-dimensional hydrodynamic and salinity model. It was calibrated and validated using 1998 and 1999 field data.

The Freshwater Introduction South of Highway 82, Little Pecan Bayou Hydrological Restoration, and South Grand Chenier Hydrologic Restoration models are all project-oriented modeling efforts. One-dimensional and two-dimensional models (namely MIKE 11 and MIKE 21 developed by the Danish Hydraulic Institute) were used in these projects. Although these modeling efforts are useful in analyzing and evaluating proposed local restoration efforts, they could not reflect the region-wide impact of any of these proposed restoration strategies.

The East Sabine Lake Hydrological Restoration and Sabine-Neches ship channel expansion modeling efforts were also developed for project specific objectives and although useful for their purpose, they also cannot be used to develop a regional understanding of the hydrology nor the ecology.

In order to develop an understanding at the regional scale, and in order to evaluate restoration and management strategies at the sub-province scale, a hydrodynamic and ecological

numerical model needs to be developed. Prior to developing such a model, a thorough water, sediment and salinity budget analyses need to be performed to determine the volumes of fresh and saline waters entering and leaving the system, as well as the sources and distribution of sediment.

16.5 Data Gaps

The preliminary evaluation of the exiting data, identified the following gaps as the most detrimental to the development of a sub-province hydrodynamic and ecologic numerical model:

- Surveying data for the four major lakes, namely, White, Grand, Calcasieu, and Sabine lakes do not exist (at least not recent data).
- Adequate marsh-elevation data is not available everywhere within the region.
- Adequate information regarding the sediment plume from the eastern side of the state is not available.
- Although continuous and discrete information exist, most outlets of this region are either not properly monitored or not monitored at all.
- Hydrologic and ecologic data are extremely limited for the marsh (but will be gathered through the CRMS program).

16.6 Modeling and Analysis

Filling data gaps will allow the development of additional large scale models to better predict ecosystem response in subprovince 4. These future models could include:

16.6.1 Large Scale Hydrodynamic, Salinity, and Sediment Model

This model would have a resolution of one square kilometer, similar to previous LCA models. The objective of this modeling effort is to accurately calculate the currents, salinity, and sediment for Louisiana's coast taking into account the fresh water input from the major rivers. Depending on the wind and current conditions, the fresh water entering the Gulf influences the salinity pattern in the region. The wind and currents are also the major factors that form the shape of the sediment plume coming off the major Louisiana rivers. The model will provide velocities, salinity, water level, and sediment concentrations. This information is extremely valuable to all the regional modeling currently used to assess coastal restoration strategies.

16.6.2 Sub-Province wide Hydrodynamic, Salinity, and Sediment Model:

This model would have a resolution of resolution $1/16^{th}$ square kilometer. The model will be used to develop a regional understanding of the hydrology and ecology. It will also be used to formulate restoration and management ideas and provide a quantitative assessment of their effectiveness.

16.6.3 Water, Sediment, and Salinity budget analyses

Water, sediment, and salinity budget analyses supported by surveying, monitoring and modeling effort forms the foundation for the previous two proposed plans. It is crucial to develop accurate water, sediment and salinity budgets for the system to understand the amount of fresh and saline water entering and leaving the system, and the sources and distribution of sediment.